

Converting Hydrocarbons to Recyclable Materials for Metal Replacement with Positive Hydrogen Output

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Decarbonizing the industrial sector and lightweighting transportation by making lightweight structural materials and conductors via co-production of advanced carbon materials and clean hydrogen

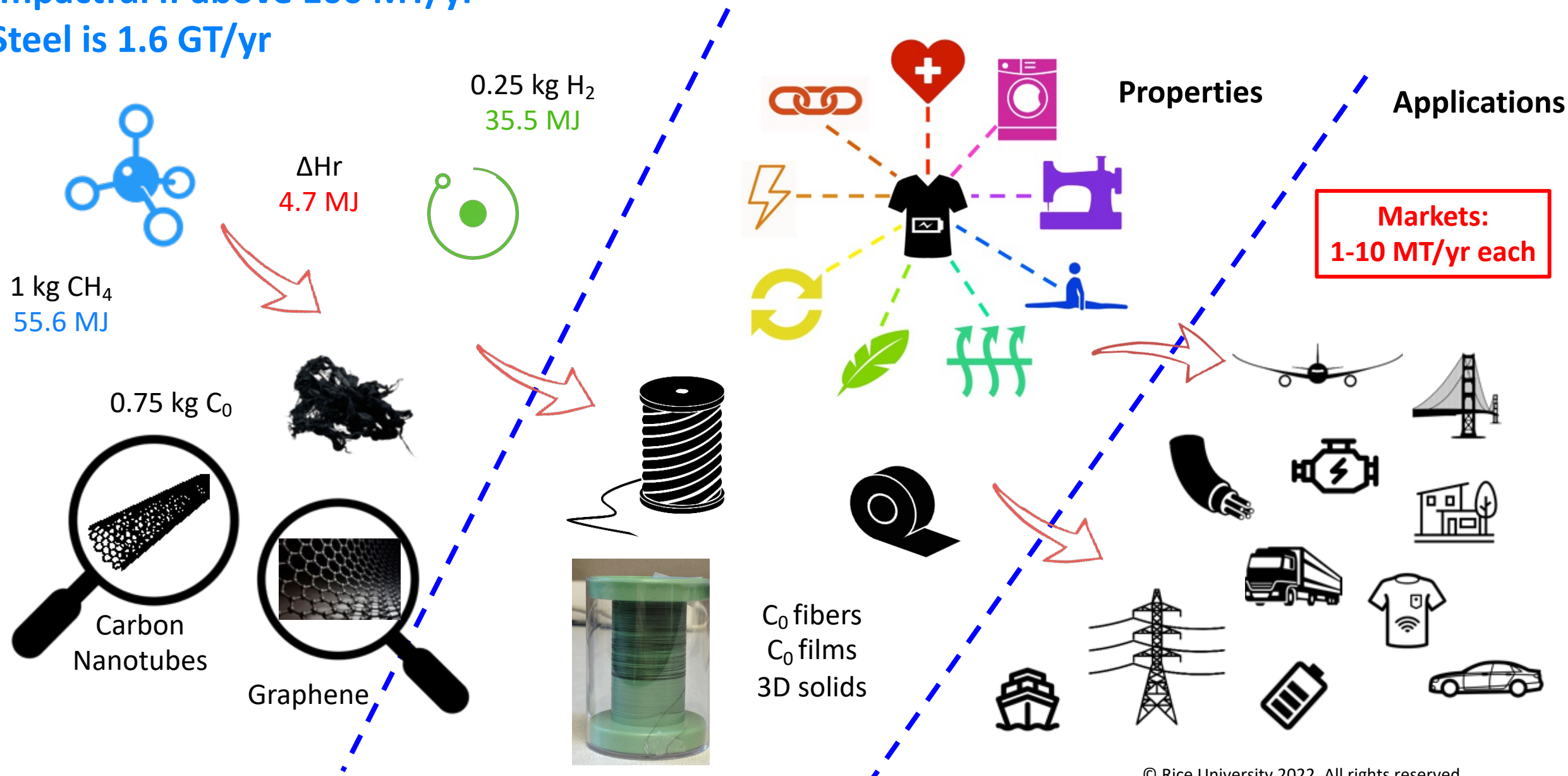
Total project cost:	\$3.45M
Length	36 mo.

* emeritus

A novel hydrocarbon pathway: materials with structural integrity

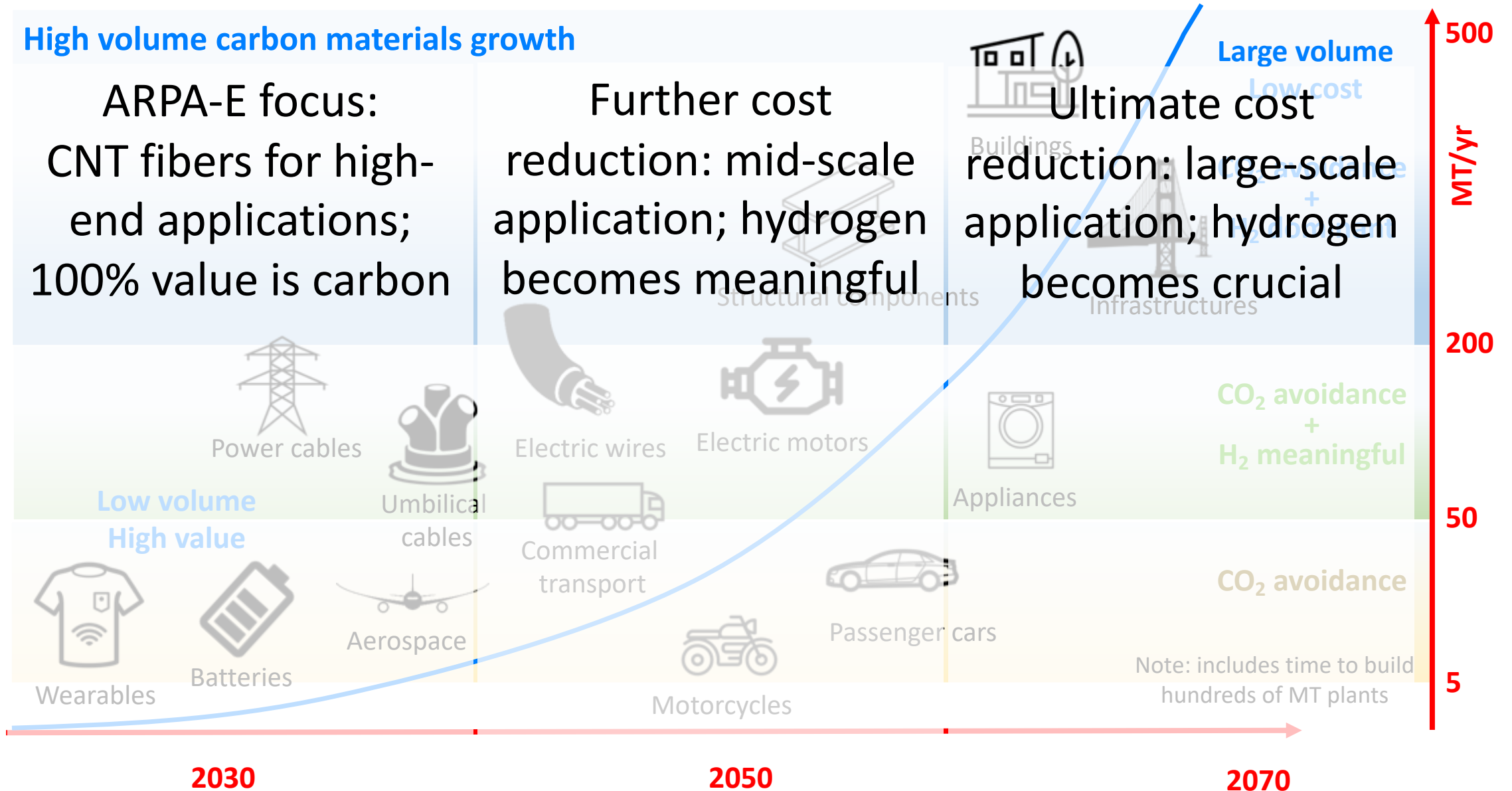
Impactful if above 100 MT/yr
Steel is 1.6 GT/yr

Pasquali and Mesters, PNAS 2021 <https://www.pnas.org/content/118/31/e2112089118>



Valuation of carbon vs. hydrogen co-products: Carbon First

Pasquali and Mesters, PNAS 2021 <https://www.pnas.org/content/118/31/e2112089118>



Team



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Matteo Pasquali



Glen Irvin



Leonardo Spanu



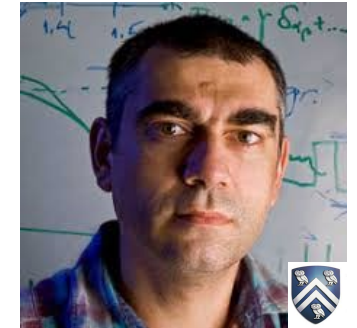
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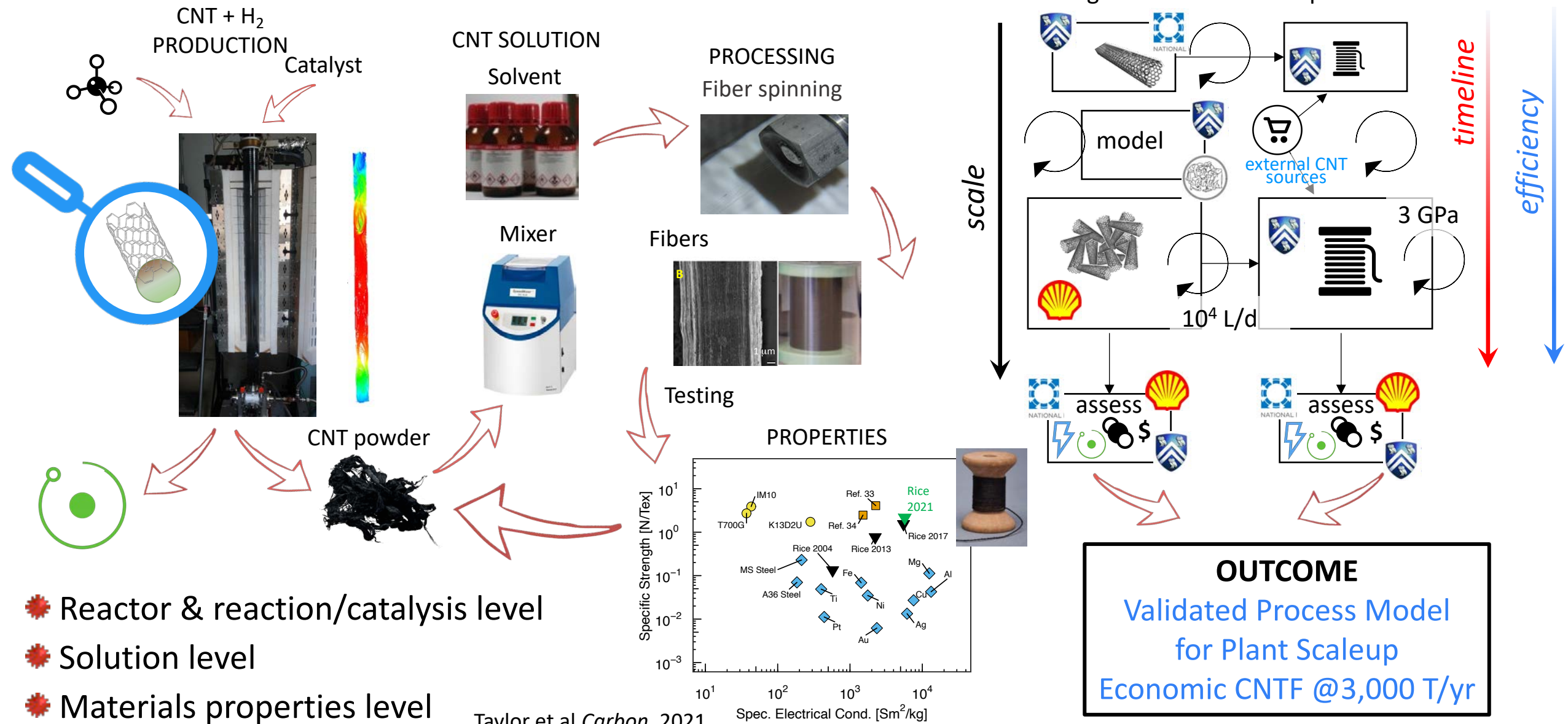
Joe Powell*

(*retired)

Program Flow



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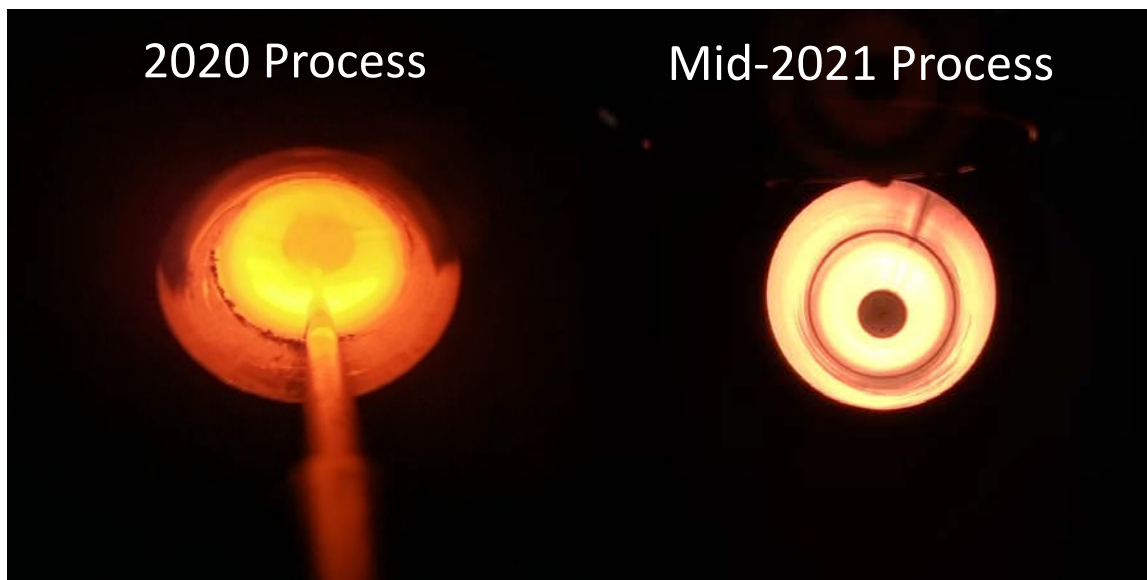
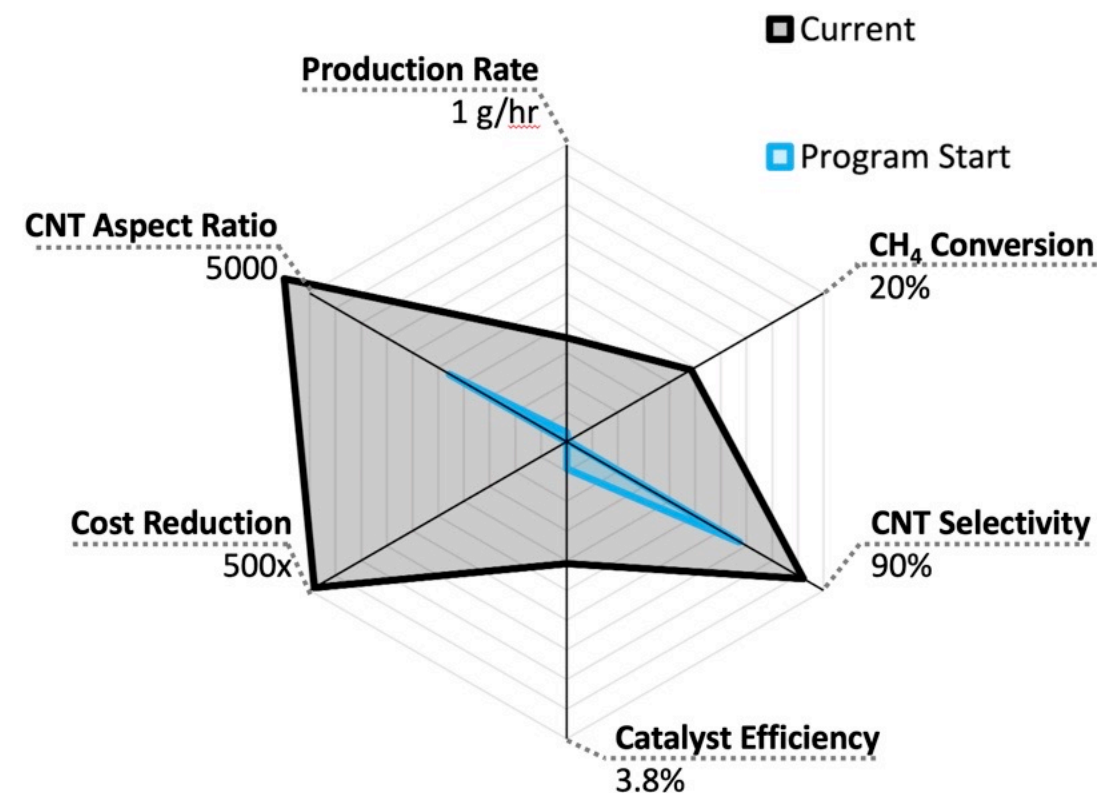
- Reactor & reaction/catalysis level
- Solution level
- Materials properties level

Taylor et al, Carbon, 2021

<https://www.sciencedirect.com/science/article/abs/pii/S0008622320307193>

OUTCOME
Validated Process Model
for Plant Scaleup
Economic CNTF @3,000 T/yr

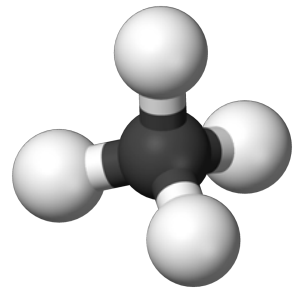
CNT synthesis: productivity improvements in 2021



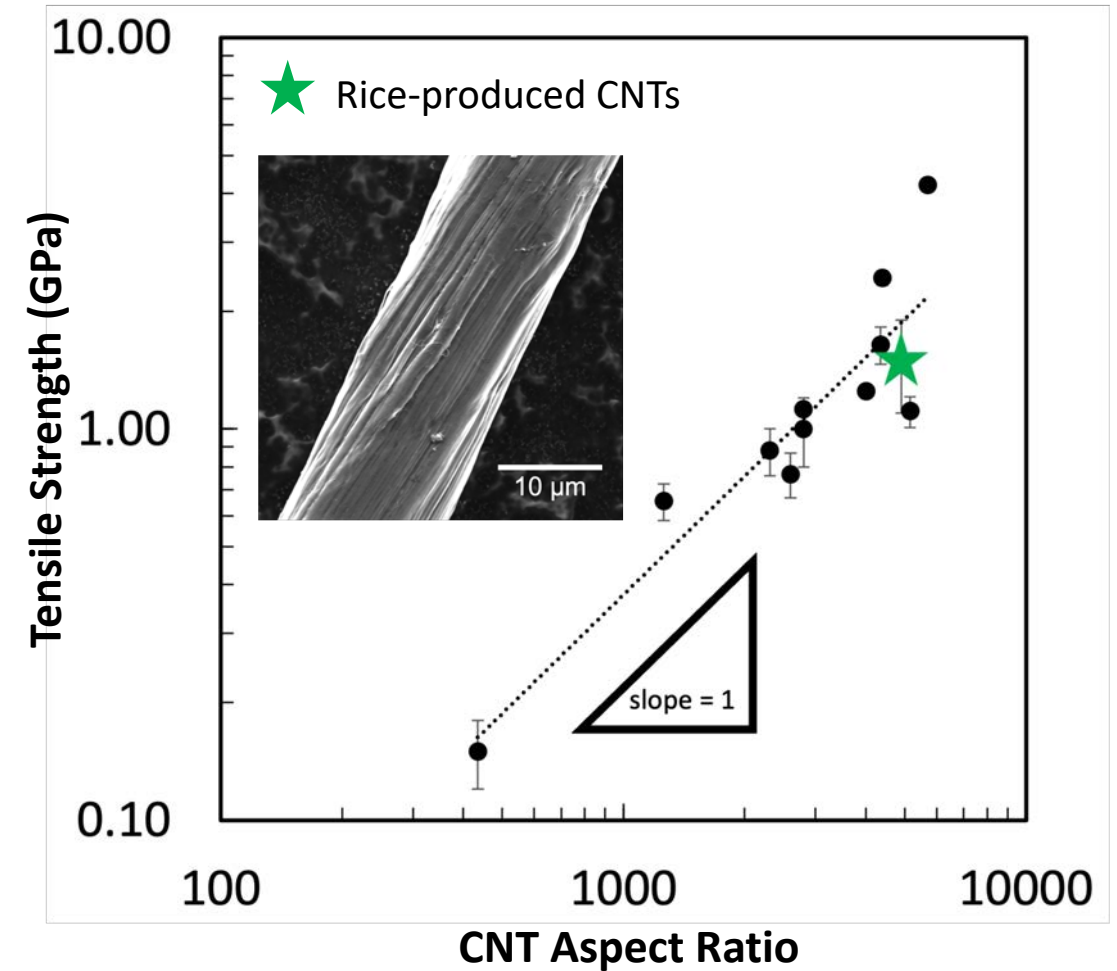
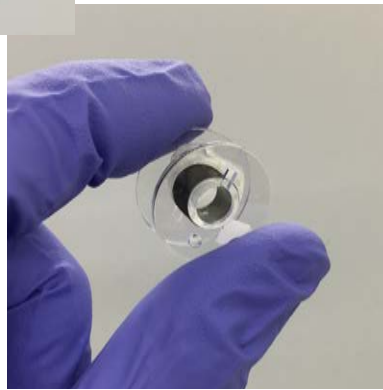
Economics & current efforts

- High dilution (being reduced)
- Flow patterns (redesigning injection)
- Process intensification

Collaboration with S. M. Kim's group (KIST)

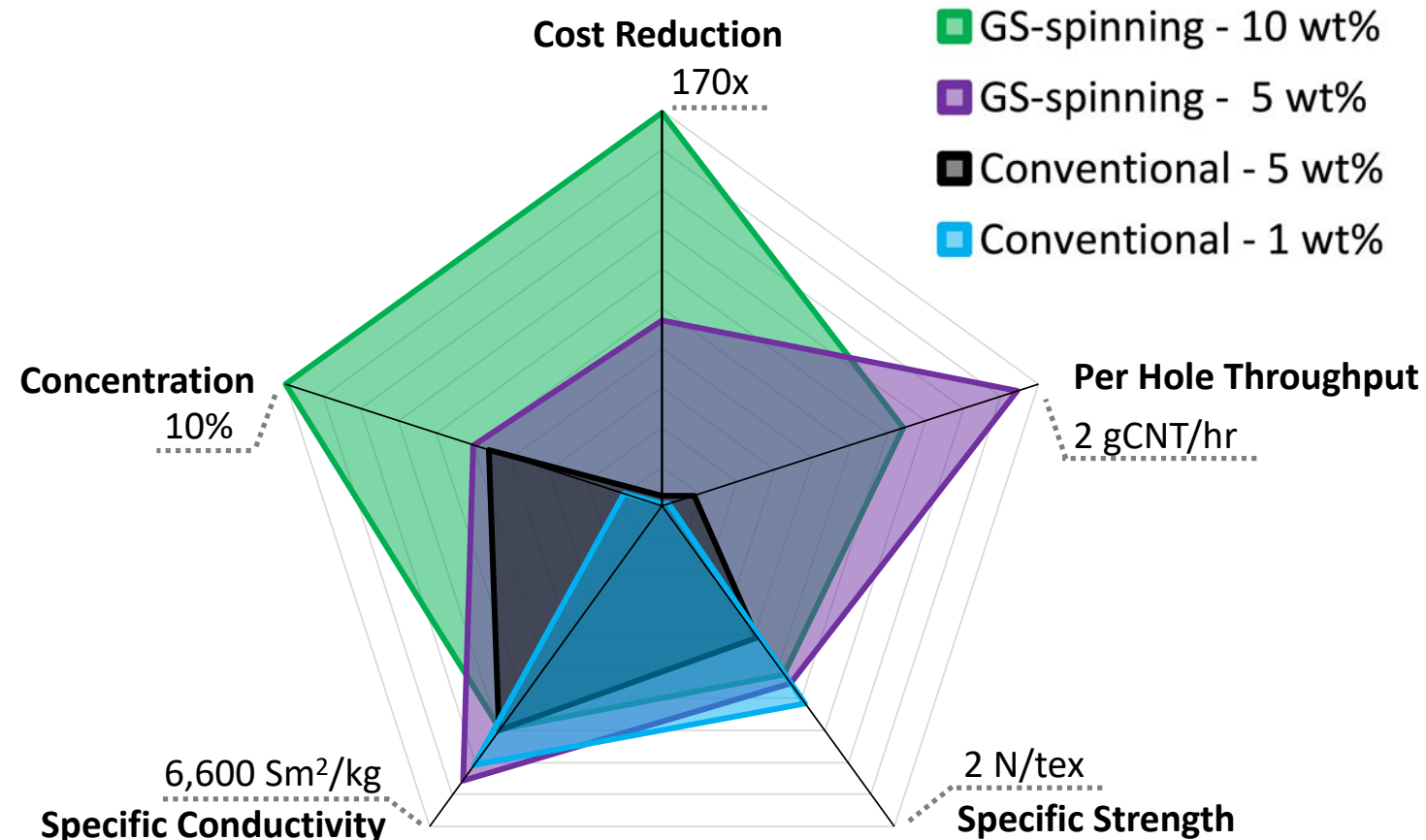
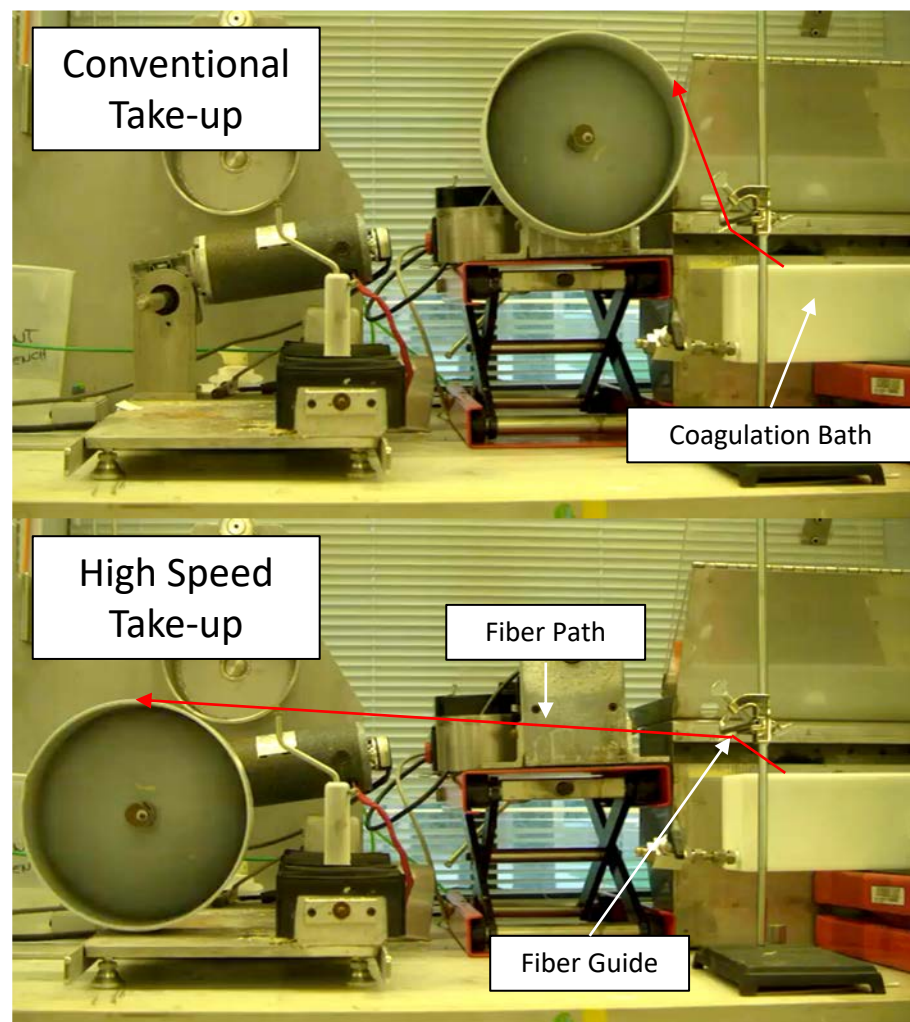


Methane to CNTs to CNT fibers



- In-house production (0.4-0.5 g/hr) is now sufficient for spinning CNT fibers comparable to SoA properties

CNT fiber spinning: improvements in 2021



Note: current process development with partner's mid-quality CNTs

Spinning @ 10wt%, Gen2 Line, In-line and Post-Stretch Capabilities Deployed

Microstructure Development & Scaling

3 GPa, 10 wt % solution



Overall Program deliverables

CNT Synthesis Process Efficiency and Scaling

\$/kg

Achievements

- Synthesis: demonstrated concurrent
 - mid-throughput production
 - high CNT selectivity & quality (translated into fibers)
- Can estimate process thermodynamic efficiency
- Spinning: demonstrated
 - high-throughput production
 - major process intensification via high concentration spinning
 - CNT fiber properties maintained at high throughput

COI: MP
owns equity
in DexMat



Biggest Challenges

- Increase methane concentration in feedstock
- Increase methane conversion (keeping selectivity)
- Decouple reaction and reactor
- “Killer app(s)”

Collaboration with DexMat, Inc. <https://dexmat.com/>

Risk Reduction Approaches

- Two catalyst delivery systems; in-line catalyst measurement & gas-phase analysis
- Flow distribution system redesign to decouple transport and kinetics
- Collaborations for source CNTs
- Collaborations for application development

Partnerships and collaboration opportunities

- carbonhub.rice.edu
- Application development: we can provide material and expertise
- CNT material conversion: we can (try to) make fibers, tapes from other's CNTs



Galvorn

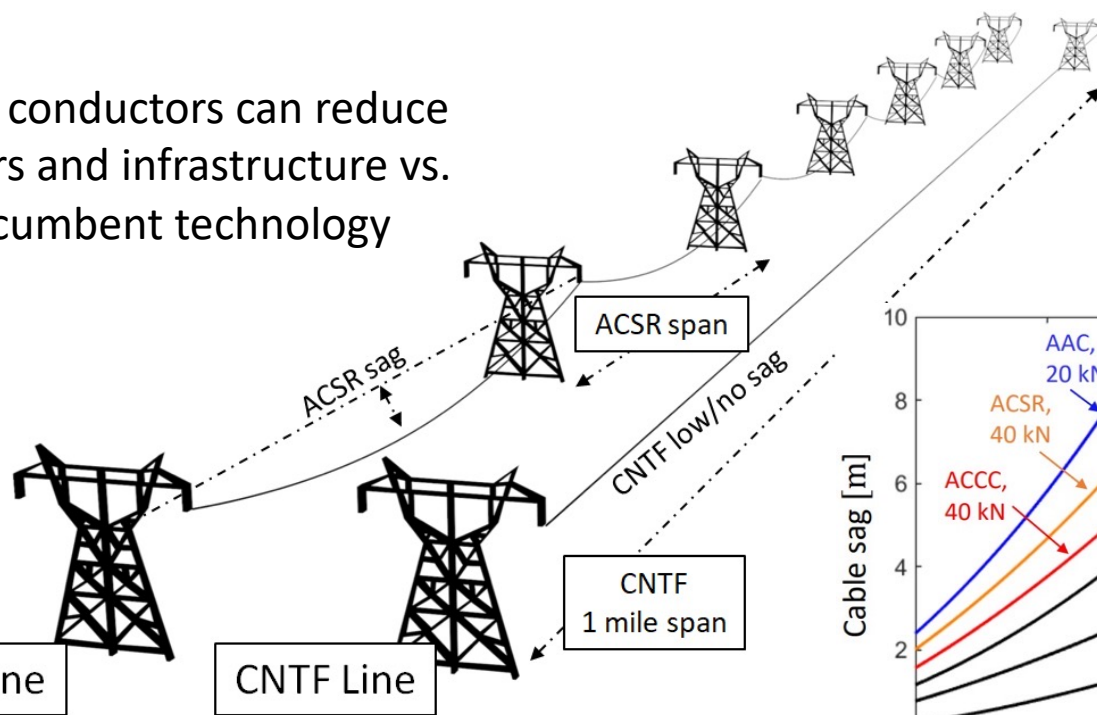
T2M: Grid Transmission Overhead Power Lines

Multiple functionalities: strength, lightweight, electrical & thermal conductivity

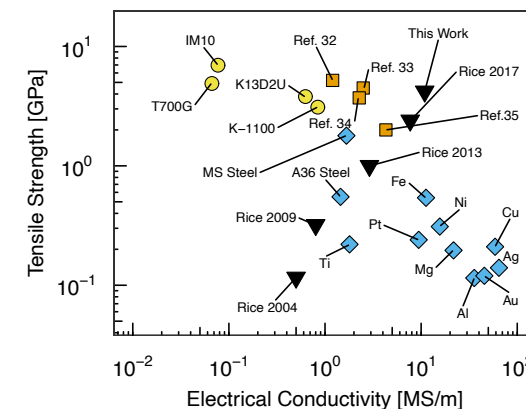
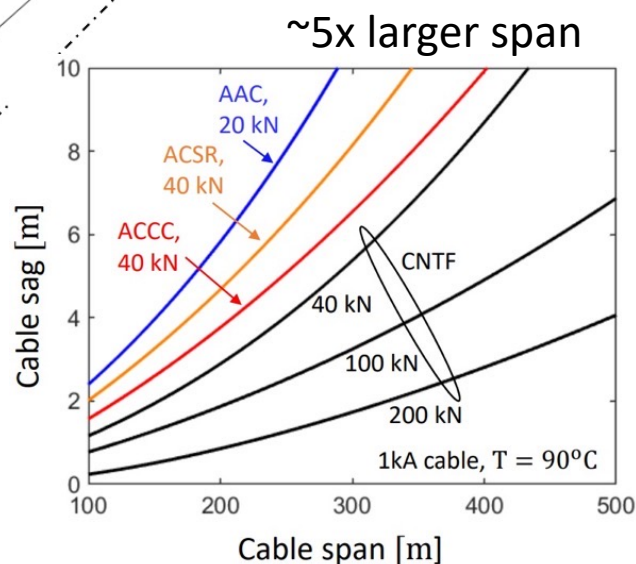
Grid transmission conductors require multiple functionalities

- Specific electrical & thermal conductivity
- Specific strength for long spans
- Market opportunity: ~3 Tons/mile (high voltage)
- Opportunity to simplify system design, lowering **Total Cost of Ownership**

CNTF conductors can reduce towers and infrastructure vs. incumbent technology

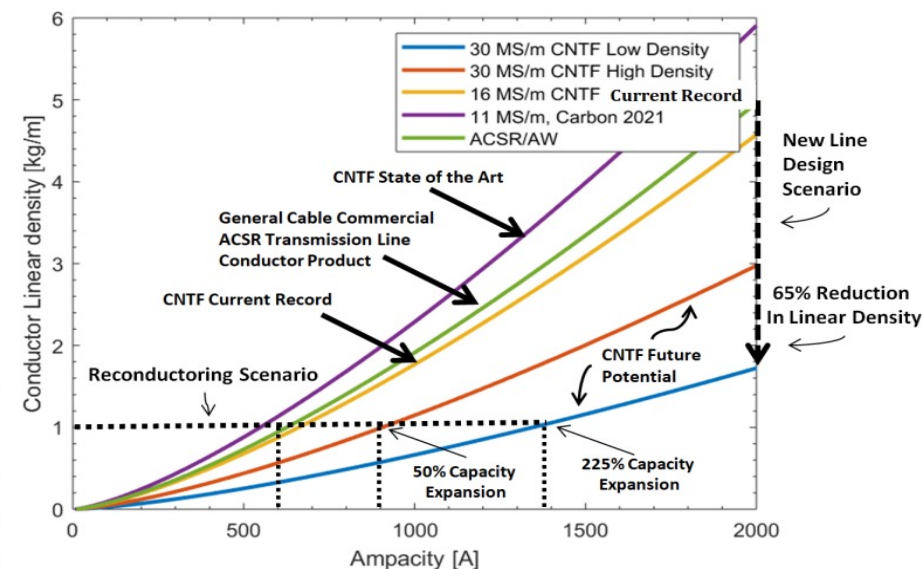


Collaboration with G. Wehmeyer, J. Kono (Rice)



Taylor et al,
Carbon, 2021

<https://doi.org/10.1016/j.carbon.2020.07.058>



Collaboration with **Prysmian Group**